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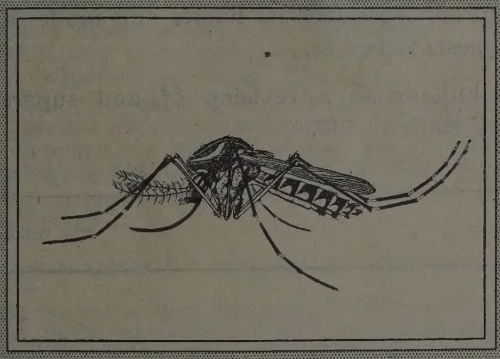
The YELLOW-FEVER MOSQUITO



UNITED STATES DEPARTMENT OF AGRICULTURE
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YELLOW FEVER apparently no longer occurs in the United States, and its occurrence with us for all future time is most unlikely, yet the so-called yellow-fever mosquito is perhaps the commonest household mosquito in the Gulf States, and it has been shown to be responsible for the carriage of dengue or so-called breakbone fever. As it is distinctly a household mosquito which is readily controlled, the importance of such control is obvious. This bulletin describes its habits and mode of life and suggests remedies.

This bulletin is a revision of and supersedes Farmers' Bulletin 547.

Washington, D. C. October, 1923

THE YELLOW-FEVER MOSQUITO.[1]

By L. O. Howard, *Chief of the Bureau of Entomology.*

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HOW TO RECOGNIZE THE YELLOW-FEVER MOSQUITO.

THE only species of mosquito which has been shown to transmit yellow fever is a small form well known in the Tropics. It is somewhat variable in size, but on the whole is so small as to require a mosquito bar of 20 strands, or 19 meshes, to the inch to prevent its entrance into screened rooms. Both males and females can pass through a netting containing 16 strands, or 15 meshes, to the inch. It is a strikingly marked, and, on the whole, when seen under the lens, a beautiful insect. Its general color is dark, but its thorax is marked with a silvery white, lyre-shaped pattern; the abdomen is banded with silvery white, and there is a silvery white spot on each side of the abdominal segments. The legs are banded alternately with black and pure white, and the long palpi of the male are also alternately banded with black and pure white. As with many other species of mosquito, the antennæ of the male are broadly feathered, while those of the female are only slightly feathered. The accompanying illustrations (Figs. 1–3) well indicate the general appearance of the insect.

POPULAR NAMES BY WHICH IT HAS BEEN CALLED.

Popularly the yellow-fever mosquito has been called in the Tropics the house mosquito, the day mosquito, the banded-legged mosquito, and is now generally known as the yellow-fever mosquito. Sometimes also it is known popularly by one of its discarded scientific names, the Stegomyia mosquito.

DOMESTICITY OF THE SPECIES.

The yellow-fever mosquito is inseparably associated with man in the Tropics. It is essentially a town mosquito, and normally it is never found at a great distance from habitations. It shows a very

[1] *Aëdes aegypti* L. Among the names by which this mosquito has been known are *Culex fasciatus, Stegomyia fasciata, Culex calopus, Aëdes calopus,* and *Aëdes argenteus.*

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decided preference for human blood, and it must have blood for the development of its eggs. Both sexes inhabit houses, and when there is a supply of water the entire life cycle takes place indoors. Its long association with man is shown by many of its habits. It approaches stealthily from behind. It retreats upon the slightest alarm. The ankles and, when one is sitting at a table or desk, the underside of the hands and wrists are favorite points of attack. It attacks silently, whereas other mosquitoes have a piping or humming note. The warning sound has doubtless been suppressed in the evolutionary process of its adaptation to man. It is extremely wary. It hides wherever it can, concealing itself in garments, working into the pockets and under the lapels of coats, and crawling up under the clothes to bite the legs. In houses it will hide in dark corners, under picture moldings, and behind the heads of old-fashioned bedsteads. It will enter closets and hide in the folds of garments.

FIG. 1.—The yellow-fever mosquito. Adult female. Much enlarged.

HABITS OF THE ADULT.

FEEDING HABITS.

The female sucks blood when it is available, and needs blood to develop her eggs. In captivity she has been kept alive for a long time on honey or other sweet substance. She is attracted to portions of the body covered with perspiration. A female will bite within 18 to 24 hours after she emerges from the pupa. Virgin females will bite, but fertilized females are more greedy. After a meal of blood she is very sluggish; she flies with difficulty, seeking a hiding place for digestion. Several hours are consumed in digestion, and then the female is anxious for another meal of blood. The species normally sucks blood repeatedly. In 31 days a female is recorded to have sucked blood 12 times. By biting a number of different individuals the chances of becoming herself infected with yellow fever and transmitting the disease are greatly increased.

The yellow-fever mosquito can subsist upon the blood of any warm-blooded animal, but shows a decided preference for man. It prefers the white race to dark races, and among the whites attacks by pref-

erence young, vigorous persons of fine skin and good color rather than anemic or aged people. It will also feed upon birds, and it has been carried alive from Brazil to Europe by being fed upon canary birds. Instances are on record of the biting of corpses.

TIME OF ACTIVITY.

The popular name in the British West Indies, "day mosquito," is derived from the fact that this species is usually active and bites only in the daytime, although, where there is a light in the room, it may also bite at night. It is especially voracious early in the morning about sunrise and again late in the afternoon. It does not bite in the bright sunlight out of doors, and, in fact, is not in evidence in the open. On cloudy days it bites at all times. Antimosquito lotions for the skin, used in unscreened houses at night, are not so apt to be effective against this species as against other semidomesticated species, such as *Culex quinquefasciatus* and the species of Anopheles, for the reason that at the time when the individual is soundest asleep, in the early morning hours, the lotion will largely have evaporated, and the yellow-fever mosquito begins to bite only when the sunlight first enters the room.

FIG. 2.—The yellow-fever mosquito: Adult male. Much enlarged.

LENGTH OF LIFE OF ADULTS.

Adult females have been kept alive for long periods by feeding them upon bananas and other fruit, upon honey, molasses, and other sweet substances. Beyond the fortieth day the mortality becomes great. They will live longer where the atmosphere is moist. Guiteras, in Cuba, kept five infected adult females alive for 101 days and one for 154 days. The oldest male that has been kept in captivity lived for 72 days. The question of how long infected yellow-fever mosquitoes may be capable of conveying the disease has received some attention. Having acquired the infection from a yellow-fever

sufferer, they are dangerous after the twelfth day and probably continue dangerous as long as they are capable of biting.

INFLUENCE OF TEMPERATURE.

The cessation of former yellow-fever epidemics in the southern United States on the appearance of the first cold weather in November and December was due to the fact that the yellow-fever mosquito is killed by cold. It is, in fact, extremely sensitive to differences in temperature. It displays the greatest activity when the thermometer is in the neighborhood of 82° F. As the temperature rises or falls a few degrees above or below that point there is a markedly reduced activity. Beyond 102° F. the heat is fatal. When the thermometer falls below 62° the mosquito becomes sluggish and will not feed. At from 54° to 57° F. it becomes torpid, flies with difficulty, and no longer stands firmly on its legs. It dies quickly when the temperature is at the freezing point. When exposed for a brief period to a temperature of 49° and then placed in a warm

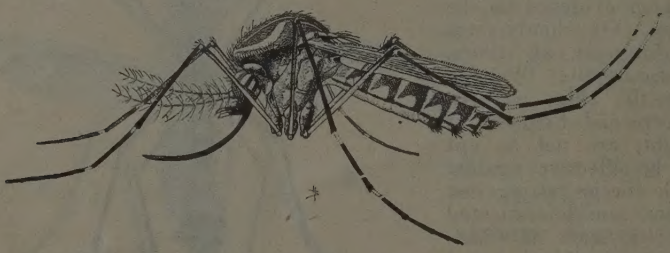

FIG. 3.—The yellow-fever mosquito: Adult female, side view. Much enlarged.

room it will revive, but it dies at a temperature of 39° maintained for more than an hour. It may be kept alive for some time at temperatures of 45° to 48° F.

DISTANCE OF FLIGHT.

The yellow-fever mosquito is a strong flier; nevertheless, it does not fly very far and, as has been already pointed out, is rarely found away from houses. It apparently never flies very high and is found by preference in the lower stories of houses. There is conflicting evidence regarding the effect of a strong current of wind on this species, and it is recorded that strong air currents produced by a mechanical ventilator had no effect upon flight. Other observers have searched for it in vain in situations exposed to the wind.

The distance of flight has an important bearing upon the distance at which ships should be anchored from fever-infected ports, but with vessels anchored at given distances it is most difficult to determine whether yellow-fever mosquitoes which may be found on board have flown from the shore or have been carried by boat parties visiting the vessel, perhaps concealed under coat collars or hidden in other parts of clothing. There is no positive evidence that vessels anchored more than half a mile from the shore will be visited by the yellow-fever mosquito by natural flight.

DISTRIBUTION BY ARTIFICIAL MEANS.

Although, as indicated in the preceding section, the yellow-fever mosquito apparently does not fly far, it is readily carried to great distances accidentally by artifical means. Vessels, once infested, may carry the species to far-distant ports. The yellow-fever mosquito has been found in New York upon vessels coming from Vera Cruz, and it is by such carriage of infected mosquitoes that the early outbreaks of yellow fever in Philadelphia and other northern cities are to be accounted for.

Railway trains also carry this mosquito, frequently in large numbers. It has spread inland from Vera Cruz, first to Cordoba and later to Orizaba, entirely by means of the railway. Almost every summer the yellow-fever mosquito is carried in railroad cars from New Orleans, Mobile, and other southern cities, on through trains, to Washington, Baltimore, and New York. It has been seen and captured on these trains by competent entomologists.

MATING.

The mating of the species usually occurs during flight, although the female sometimes alights during the act and before its completion. The act requires but a fraction of a minute. Temperature has a great influence upon sexual activity. Below 68° F. mating seldom occurs. The same male may have frequent connections in rapid succession with various females.

RELATION OF FOOD TO EGG LAYING.

It seems certain that the female can not develop her eggs without having had a meal of blood. After a meal eggs will be deposited in a few days. If a fertilized female is fed upon sweet substances, the eggs will not develop. If afterwards, say after 15 or 20 days, she is fed blood, the eggs will then develop. Blood food, however, in hastening the development of the eggs shortens the life of the mosquito. A diet of honey, on the other hand, prevents the development of the eggs and prolongs life. The shortest interval between a blood meal and egg laying is apparently two days, and the longest seven days.

BREEDING HABITS.

EGG LAYING.

The eggs are laid separately in several lots, the individual lots being laid at intervals of several days or more. They may be laid near the water, close to its edge, or upon the surface of the water. Oviposition on the surface of the water, however, is probably rare, and possibly occurs only under abnormal conditions, when the mosquitoes are being studied in captivity. Normally it appears to be the custom to lay them on the sides of a receptable containing water, just above the surface of the water, so that a slight elevation of the water will submerge them. They have been found upon a leaf floating upon the water.

Sometimes the female will lay but one lot of eggs. Others will lay two lots, and others from three to seven. According to J. R.

Taylor, the total number of eggs laid at a time varies from 35 to 114. Other observers have increased the number to 150. Undersized females rarely lay more than 50 eggs. The death of the female after egg laying seems to indicate that all the eggs have been laid.

THE EGGS.

The eggs are small and black in color and are well shown in Figure 4. As has been stated, they are ordinarily laid above the margin of the water, and here they may remain dry for long periods, hatching when reached by the water. They develop better after having been dry for some time. In fact, it seems that they will preserve their vitality dry for six months or even longer. Freezing does not destroy the fertility of the eggs. The duration of the egg stage, when the eggs are laid upon the water, is about two days; when deposited above the water they hatch promptly when submerged. When laid upon the surface of the water they are easily sunk by any disturbance, and when they sink hatching is retarded and often some of the eggs do not hatch, particularly if the temperature of the water is rather low. When submerged soon after being laid on the surface of the water they generally perish.

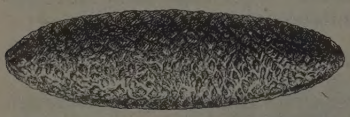

FIG. 4.—The yellow-fever mosquito: Egg. Greatly enlarged.

BREEDING PLACES.

The probabilities are that the yellow-fever mosquito originally bred in water in holes in trees, but it has so perfectly adapted itself to the human species that it has become a true domestic insect and is practically dependent for its existence upon the conditions that surround human habitations. This adaptation is undoubtedly of very ancient development. The yellow-fever mosquito is essentially a town mosquito, and the larvæ are found practically exclusively in artificial receptacles in and about houses. It can be said that its larvæ are never found in swamps, in pools, or even in temporary puddles, even when these are in close proximity to houses. In the Tropics the large earthen jars in which drinking water is kept are the most frequent and unfailing habitat of the larvæ. Rain-water barrels are abundant breeding places. Rain-water tanks, so universally behind the houses in southern cities like New Orleans, Galveston, and Mobile, are the source of most abundant supplies of these mosquitoes. The larvæ are also found in sagging gutters containing rain water, in tin cans, in cesspools, in horse troughs, in water-closet tanks, in the drain traps of stationary washstands, in the urns in cemeteries, in the holy-water fonts in churches, in pools accumulating under the water tanks, in water pans in the chicken yards, and in the water receptacles of grindstones.

The observations of Busck and Knab in the West Indies and Central America indicate that the yellow-fever mosquito breeds preferably in clear water although occasionally in foul water. These observers always found it in artificial receptacles, except a few times

in tree holes near houses, and in one case in a street gutter. In the last case it is probable that this larva came into the gutter by the emptying of some household vessel. Discarded bottles and tins about houses are favorite breeding places. The larvæ occur in tree holes only when the latter are in close proximity to human habitations.

BEHAVIOR OF LARVÆ.

The larvæ (Fig. 5), when suspended from the surface film of the water to take in air, hang almost perpendicularly. They are very easily alarmed and then go quickly to the bottom, where they remain a considerable time. They can live under water for a long time without rising to the surface. When water is poured from a receptacle inhabited by these larvæ they quickly seek the bottom, and their presence may not be suspected, although the vessel is in constant use. They cling so closely to the bottom that unless the jars are rinsed and tipped up so as to empty them completely, which is not usually done, nearly all the larvæ will remain in the jars. On account of this habit they are not easily disposed of by pouring out the contents of a barrel.

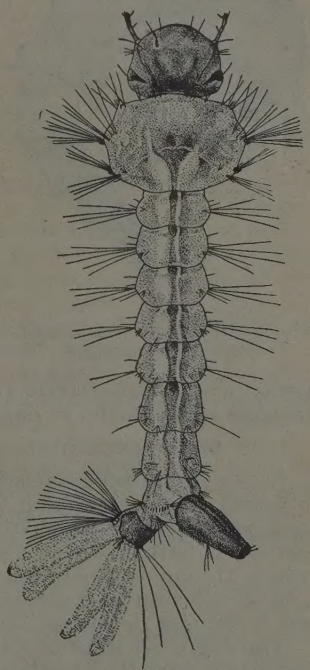

FIG. 5. — The yellow-fever mosquito: Larva. Much enlarged.

FOOD HABITS OF LARVÆ.

The larvæ occur most frequently in clear water in rain-water barrels or in drinking-water receptacles in houses. The water in such receptacles contains more or less animal matter as well as vegetable refuse, and such probably is generally the food of the larvæ. The larvæ feed at the bottom, where they mouth over the organic sediment, even when the water is very deep. Larvæ in confinement may be observed chewing vigorously on dead insects or larval or pupal cast skins. They are sometimes cannibalistic, the larger larvæ devouring the smaller ones.

The growth of yellow-fever mosquito larvæ is hastened by the presence of a small amount of fecal matter in the water. Observers in Habana at the time of the Cuban war found that the larvæ which bred in the tin cans used for carrying away human excrement from the hospitals developed rapidly, and other observers have recorded the fact that by adding fecal matter to the water in which were larvæ under observation the development was hastened until the life cycle was completed in from six to eight days.

DURATION OF EARLY STAGES.

Temperature has the greatest influence not only upon the hatching of the eggs but also upon the subsequent development of the larvæ. The effects of various temperatures on the early stages were carefully investigated by the American commission in Cuba and by the French commission in Rio de Janeiro, and the results of both agree very closely. The shortest period of development to imago observed by Reed and Carroll during summer weather in Cuba was 9½ days, divided as follows: Incubation, 2 days; larval stage, 6 days; pupal stage (Fig. 6), 36 hours. This, however, was believed to be exceptional. In average summer temperature the time required for the complete metamorphosis ranges ordinarily from 11 to 18 days. The French observers in Rio de Janeiro found that the most favorable season for rapid development was when the night temperatures ran from 79° to 81° F. and the day temperatures from 82° to 88° F. They found that some of the larvæ of this mosquito reached the pupal stage seven days after the hatching of the eggs, and the adult condition on the ninth day, and that generally most of the larvæ from the same laying of eggs produced imagoes about the tenth day.

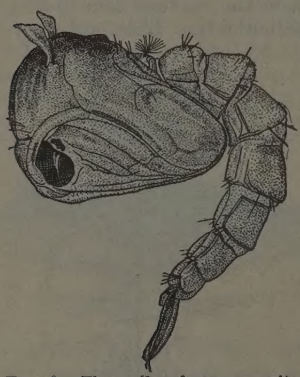

FIG. 6.—The yellow-fever mosquito: Pupa. Much enlarged.

RESISTANCE OF LARVÆ TO ADVERSE CONDITIONS.

Larvæ of the yellow-fever mosquito have been found in nature in brackish water containing 35 per cent of sea water. With 40 per cent sea water the larvæ still survived and produced imagoes. Experiments have shown that the larvæ may in nature survive in water which through evaporation has reached a high degree of salinity, and if afterwards through rains the water becomes again diluted the larvæ may develop to imagoes.

The degree of resistance to desiccation of both larvæ and pupæ is important from the practical standpoint. The first yellow-fever commission to Vera Cruz found that in that dry climate larvæ died quickly when the water containing them was poured on the ground. In moist climates the larvæ may, under favorable circumstances, live out of water a considerable time, and the pupæ show great resistance to drying. Experiments made by Peryassu in Brazil showed that when larvæ were placed upon filter paper none lived nine hours. When placed upon moist ground, according to temperature and evaporation, they survived as much as 13 days, and when again put in water developed to imagoes. Pupæ dried upon filter paper survived up to 9 hours and 30 minutes.

GEOGRAPHIC DISTRIBUTION.

In considering the geographic distribution of the yellow-fever mosquito it should be pointed out at the start that it has two dis-

tinct regions—one in which it is capable of breeding continuously and another over which it spreads during warm weather, to be annually exterminated by cold after breeding for an indefinite number of generations. The first may be termed the permanent region and the second the temporary summer region. The permanent distribution is limited in a general way by the frost line. Where frost does not occur the species generally may breed permanently. As has been already shown, this mosquito does not thrive below a temperature of 80° F., so that in a uniform climate with a temperature much below 80° the species will not continue to exist. Such climates are rare, however, in regions where frost never occurs.

The temporary summer distribution is determined by the means of carriage that happen to be available. It has been shown that the yellow-fever mosquito is a domestic species, having a fairly long life in the adult stage and having the custom of hiding itself in the most ingenious ways. It is therefore particularly subject to carriage for long distances on board vessels, in railway trains, and even packed securely away in baggage. In the old days of sailing vessels on very long voyages it was not only possible for the yellow-fever mosquito to breed continuously in the more or less exposed water supply of vessels, but undoubtedly this was of common occurrence. Every year it is carried to the north in the United States upon railway trains and may breed for a generation or so hundreds of miles north of its permanent breeding places. Thus while the species breeds permanently only in the extreme southern portion of the United States, it will be found every summer breeding for a generation or so in localities to which it has been carried by trains. In 1904, for example, it was found breeding abundantly upon the grounds of the St. Louis exposition, and had one or more persons suffering with incipient yellow fever come to the exposition the mosquitoes were there in numbers to carry the disease. Everywhere almost throughout the southern United States in midsummer will this mosquito be found, and this explains why epidemics of yellow fever have occurred in years past on the Atlantic coast of North America even as far north as Montreal.

On the Pacific coast, on the other hand, the nights are so cold that this species does not seem to be able to survive. This applies to points north of San Diego. This species breeds permanently in all of the west coast Mexican seaports, and must frequently be brought to the California coast in vessels, but it has never been known to breed there. This seems at first sight strange, since the mean annual temperature of California is much above that of eastern cities where epidemics have occurred, and in San Diego and Los Angeles one sees tropical vegetation on every hand growing unprotected, and severe cold is unknown; yet the nights are cold even in the summer, and it is to this condition—the low minimum nightly temperatures—that freedom from the yellow-fever mosquito, and consequently from yellow-fever epidemics, is due.

ORIGINAL HOME.

The original home of the yellow-fever mosquito must clearly be identical with that of yellow fever. Early history points very strongly to the West Indies and the adjacent mainland as that origi-

nal home. There has been much discussion of the question, and ingenious arguments have been adduced to prove that yellow fever is of African origin and was imported into America through the slave trade. All things considered, however, the probabilities are that yellow fever is one of the very old diseases of mankind in the New World, and that it was taken from the New World to the Old.

RELATION TO YELLOW FEVER.

DISCOVERY OF THE RELATION.

Physicians had been theorizing about the cause of yellow fever from the time when they began to treat it. It was thought by many that it was carried in the air, by others that it was conveyed by the clothing, bedding, or other articles which had come in contact with yellow-fever patients. There were one or two early suggestions of the agency of mosquitoes, but practically no attention was paid to them, and they have been resurrected and considered significant only since the beginning of the present century.

With the discovery of the agency of microorganisms in the causation of disease, a search soon began for some causative germ of yellow fever. Many microorganisms were found in the course of autopsies and many claims were set forth by investigators. All of these, however, were virtually set at rest by Sternberg in his "Report on the Etiology and Prevention of Yellow Fever," published in 1890. But a claim made by Sanarelli in June, 1897, for a bacillus which he found in 58 per cent of yellow-fever cases, and which he called *Bacillus icteroides*, received considerable credence. This was found afterwards by several investigators in considerable abundance, but later it was shown by Reed and Carroll that the organism in question is identical with the bacillus of hog cholera and is in no way concerned with yellow fever.

In 1881 Dr. Carlos Finlay, of Habana, proposed the theory that yellow fever, whatever its cause may be, is carried by means of a certain mosquito from man to man. His original paper shows that he had carefully studied the habits of house mosquitoes and had determined all of the factors in the life history of the species now known as the true yellow-fever mosquito which have since been shown to be essential in its rôle of transmitter of the disease. It was this careful study of the mosquito and the disease, conducted through many years in the most favorable locality, the city of Habana, that gave him a firm conviction that the two were interdependent. On this account his theory has true scientific merit. It was based on intensive study, and not, as had been the case with his predecessors, on vague suspicions. Subsequently he published a number of important papers, in which his views were modified from time to time. He thought out carefully the question of immunization and concluded that this might be brought about by mild infection through the bite of a single mosquito. In one of his papers he published experiments with 100 individuals, producing three cases of mild fever. None of the cases, however, was under his full control; and as the possibility of other methods of contracting the disease was not excluded, his claims were not accepted.

In 1900 the facts were determined by scientific methods. An American Army being at that time stationed in Cuba, a medical board was appointed by Surgeon General Sternberg for the purpose of investigating the acute infectious diseases prevailing in the island. The board consisted of Walter Reed, James Carroll, Jesse W. Lazear, and Aristides Agramonte. Doctor Reed was the chairman of the board. In the course of the work yellow fever naturally received the main measure of attention. The claims of Sanarelli's *Bacillus icteroides* were disproved, and Reed and his associates began a careful and thoroughly scientific investigation of the possibilities of mosquito carriage of the disease. Experiments carried on by the board were as perfect in their methods as it was possible for scientific acumen and hard common sense to make them. Every possible element of error seems to have been guarded against. The final and conclusive tests made during the autumn of 1900 were conducted with a spirit of earnestness, self-sacrifice, and enthusiasm which affected everyone connected with the work, even in the most subordinate positions, private soldiers not only offering themselves for the presumably dangerous tests, but insisting that they should be accepted as subjects for experimentation. Doctor Reed, the master spirit of the investigation, was, moreover, a man above all men for this work, no less in his ability to compel the greatest confidence and enthusiasm than in the absolutely complete manner in which the experiments were conducted. While the work was going on criticism was invited and urged from Habana physicians, from visiting surgeons, and from everyone interested, but so perfect were the plans that it seems impossible that any criticism could have been made.

An experimental sanitary station was established in the open, a mile from Quemados. Two houses were built, tightly constructed, with windows and doors protected by wire screens. In one of these houses soiled sheets, pillowcases, and blankets were used as bedding, and this bedding was brought straight from the beds of patients sick with yellow fever at Habana. For 63 days these beds were occupied by members of the Hospital Corps for periods varying from 20 to 21 days. At the end of this occupation the men, who were all nonimmunes, were taken to quarantine for five days and released. Not one of them was taken ill. All were released in excellent health. This experiment was of the greatest importance, as it demonstrates that the disease is not conveyed by fomites; hence the disinfection of clothing, bedding, or merchandise formerly supposed to have been contaminated by contact with yellow-fever patients is unnecessary. This disinfection work, which hitherto had been carried to the extreme in the case of yellow-fever epidemics in our Southern States, was shown to have been perfectly useless.

In the other house, which was known as the "infected mosquito house," there were no articles which had not been carefully disinfected. The house contained two rooms, and nonimmunes were placed in both rooms. In one room, separated from the other by a wire screen partition, mosquitoes which had bitten yellow-fever patients were introduced. In the other room they were excluded. In the latter room the men remained in perfect health. In the mosquito room 50 per cent of the persons bitten by infected mosquitoes (that had been kept 12 days or more after biting yellow-fever pa-

tients) were taken with the disease, and the yellow-fever diagnosis was confirmed by resident physicians of Habana who were above all others familiar with the disease in every form. Persons bitten by mosquitoes which had bitten a yellow-fever patient within less than 12 days did not contract the disease. In another series of experiments seven persons were bitten by infected mosquitoes by placing the hand in a jar containing the insects, and five of them, or 71 per cent, contracted the disease.

It was also found that yellow fever was produced by the injection of blood from the general circulation of a patient. Subcutaneous injections of 2 cubic centimeters of blood were followed by the disease, and the definite conclusions were reached that the parasite of yellow fever must be present in the general circulation, at least during the early stages of the disease, and that yellow fever may be produced, like malarial fevers, either by the bite of the mosquito or by the injection of blood taken from the general circulation. From these results the important corollary was reached, to quote Doctor Reed's own words:

> The spread of yellow fever can be most effectually controlled by measures directed to the destruction of the mosquitoes and the protection of the sick against the bites of these insects.

Rather recently Dr. Hideyo Noguchi, of the Rockefeller Institute for Medical Research, has isolated a spirochete which he considers to be probably the causative organism of the disease, and this conclusion is shared by Dr. Simon Flexner and other prominent pathologists.

SUBSEQUENT DEMONSTRATION.

The finality of the work of the American Army commission was almost immediately accepted by sanitarians throughout the Tropics. Measures were at once instituted in the city of Habana, then under American control, looking to the eradication of yellow fever through antimosquito measures. The enormous success of this work, carried on under the direction of the late Surgeon General W. C. Gorgas, is a matter of history, and by the use of similar methods the same efficient sanitarian afterwards wiped out yellow fever in the Isthmian Canal Zone. Similar work has been done by the sanitary officials in Brazil, in Mexico, and other countries.

A striking instance of the value of this discovery was shown during the yellow-fever outbreak in New Orleans in 1905. Down to the middle of June of the summer of 1905 this outbreak threatened to parallel the disastrous outbreak of 1878, and even to exceed that disaster in severity. Antimosquito measures were undertaken, however, and pushed with great energy and with much expenditure of funds, the result being a perfectly obvious saving of from 3,000 to 4,000 lives during that summer which would undoubtedly have been lost six years earlier.

RELATION TO DENGUE OR SO-CALLED BREAKBONE FEVER.

Dengue is a specific fever of warm countries, occurring usually as a rapidly spreading epidemic, characterized by a suddenly developed primary fever of about three days' duration, succeeded by a quiescent

period, and this again by a milder secondary fever, accompanied by an eruption. Severe pains resembling rheumatism are a prominent symptom. In its active form this disease lasts about a week, but is attended with little mortality. The particular species of mosquito which is considered in this bulletin is responsible for the spread of this fever. The epidemic of dengue which occurred in the southern United States in the summer of 1922 affords a pointed argument for the control of this mosquito. It is estimated that there were at least 200,000 cases during this epidemic.

REMEDIES FOR MOSQUITOES.

PREVENT BREEDING.

Abolish standing water wherever possible. The all-important method of reducing the numbers of mosquitoes is to eliminate the places in which they can breed. In the case of the yellow-fever mosquito and other domestic mosquitoes this is usually more easily accomplished than for mosquitoes which breed in swamps and similar places. On the other hand, every imaginable receptacle that may contain even a very little water must be found and attended to, and this means a thorough survey of the premises, both indoors and outdoors. Keeping in mind the information in this bulletin relating to breeding places, search carefully for all such places and, wherever possible, abolish the standing water by carting away chance receptacles, by emptying vessels, and by filling in excavations.

Where standing water can not be abolished, use one of the following measures:

Screen the openings to rain-water barrels, tanks, and cisterns to prevent mosquitoes from laying their eggs in them.

Sprinkle the water with ordinary kerosene of low grade, or of the grade known as fuel oil, so that an iridescent film of the oil will cover the surface and suffocate the immature forms (larvæ and pupæ) that come to the surface to breathe. This treatment also protects the water from egg laying by mosquitoes. It should be repeated every two weeks, as the film will evaporate in time. An ounce of kerosene to 15 square feet of surface is about the right proportion.

Introduce fish into fountains and artificial pools which it is not desirable to treat with kerosene or to cover with screening. The common goldfish and silverfish destroy mosquito larvæ; so also do top minnows and certain other fish.

PROTECT YOURSELF AGAINST BITES.

The use of wire screens with not less than 20 strands to the inch excludes adult mosquitoes from houses, rooms, and porches, and where the house is not screened and mosquitoes are troublesome bed canopies are advisable. Houses may be cleared of adult mosquitoes by burning in tightly closed rooms 1 pound of pyrethrum powder or 2 pounds of sulphur for each 1,000 cubic feet of contained space.

For a fuller discussion of the general subject of mosquito remedies the reader is referred to Farmers' Bulletin 444, Remedies and Preventives Against Mosquitoes, which may be obtained by applying to the Secretary of Agriculture, Washington, D. C.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

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